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Potential gains from carbon emissions trading in China: A DEA based estimation on abatement cost savings[☆]

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ABSTRACT

China has recently launched its pilot carbon emissions trading markets. Theoretically, heterogeneity in abatement cost determines the efficiency advantage of market based programs over command and control policies on carbon emissions. This study tries to answer the question that what will be the abatement cost savings or GDP loss recoveries from carbon emissions trading in China from the perspective of estimating the potential gains from carbon emissions trading. A DEA based optimization model is employed in this study to estimate the potential gains from implementing two carbon emissions trading schemes compared to carbon emissions command and control scheme in China. These two schemes are spatial tradable carbon emissions permit scheme and spatial–temporal tradable carbon emissions permit scheme. The associated three types of potential gains, which are defined as the potential increases on GDP outputs through eliminating technical inefficiency, eliminating suboptimal spatial allocation of carbon emissions permit, and eliminating both suboptimal spatial and temporal allocation of carbon emissions permit, are estimated by an ex post analysis for China and its 30 provinces over 2006-2010. Substantial abatement cost savings and considerable carbon emissions reduction potentials are identified in this study which provide one argument for implementing a market based policy instrument instead of a command and control policy instrument on carbon emissions control in China.

1. Introduction

China is a key player in international climate negotiations since it is the world's largest carbon emitter. As long as climate change continues to be one of the priorities on the international political agenda, China will continue facing enormous domestic pressures to control its carbon emissions and international pressures to commit to a mandatory carbon emissions target [47]. In the 2009 Copenhagen climate change summit, Chinese government announced a goal to decrease its carbon emissions per unit of GDP (carbon emissions intensity) by 40–45% by 2020 compared with the 2005 level. To achieve this goal, Chinese government had implemented several regulations on energy conservation and carbon emissions control since 2006. The 11th Five Year Plan (FYP) (2006-2010), which was adopted as the general guidance for China's economic and social development each five years, had put forward a national target to reduce the energy consumption per unit of GDP (energy consumption intensity) by 20% by the end of 2010 compared with 2005. This energy consumption intensity reduction target was additionally disaggregated and assigned to each province of China, which ranges from 16% to 22% reduction across different provinces. In the 12th FYP (2011–2015), Chinese government further set a target of reducing carbon emissions intensity by 17%, associated with a 16% energy consumption reduction target, by the end of 2015 compared with 2010. These national targets had also been disaggregated and assigned at the regional level for China's provinces as their mandatory energy conservation and carbon emissions reduction constraints over provincial economic development.

To realize the joint goal of economic growth and carbon emissions control, Chinese government is attempting to adopt various policy instruments including command and control policies and market based policies. The national carbon emissions intensity reduction goal and its assignment to China's each province were considered as the command and control policy instrument for carbon emissions reduction which was mainly implemented both in the 11th and 12th FYP periods. Another

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approach for pollutant emission control is known as market based regulatory strategy that sets the stage for the use of tradable permit system to achieve a reduction in pollutant emission at minimal cost, for example, the U.S. tradable permits program for SO_2 started with the enactment of the Clean Air Act [37], and the EU Emissions Trading System (EU ETS) established as a tool for reducing greenhouse gas emissions cost-effectively [54]. Nevertheless, China has just recently (June of 2013) launched its pilot markets for carbon emissions trading in selected seven provinces/ municipalities (Shenzhen, Beijing, Shanghai, Tianjin, Guangdong, Chongqing and Hubei), and the carbon emissions trading scheme is still at the pilot experiment stage. Although a nationwide carbon emissions trading system has not yet established, with the experiences from the pilot markets, China is prompting to establish a unified national carbon emissions trading system during 2016–2020 [31].

As pointed out by Färe et al. [12,13], with the implement of tradable permit programs, concerns arise over what are the potential gains from pollutant emissions trading. The potential gains also can be seen as carbon emissions abatement cost savings, or reductions on economic output loss caused by carbon emissions control, when implementing market based instrument such as carbon emissions trading scheme instead of command and control policy. Theoretically, heterogeneity in abatement cost determines the efficiency advantage of market based instruments such as carbon emissions permits trading over command and control policies on carbon emissions. The carbon emissions permits market offers companies or facilities that facing high marginal emissions abatement costs the opportunity to purchase the right to emit CO_2 from companies or facilities with lower abatement costs, and thus this instrument is expected to yield abatement cost savings compared to the command and control instrument to carbon control regulation [2]. In other words, carbon emissions permits trading takes advantage of the fact that emissions abatement costs vary across firms and utilities and encourages firms and utilities with lower carbon emissions control costs to undertake more CO_2 reductions. In addition, since each individual entity has the flexibility to choose the course of action for achieving abatement compliance at its least cost, investment in technology or procedure for abatement would flow to where has the lowest abatement cost, the marginal abatement cost becomes equalized across all entities [3,15], and therefore, the CO_2 abatement target is achieved at the lowest cost. This is the reason that emissions permits trading is generally considered a cost effective form of abatement policy instrument.

Since different Chinese provinces usually have various economic growth modes, natural resource endowments and energy consumption patterns, industrial structures and technological levels, the carbon emissions abatement cost of different Chinese provinces are also likely to be different [9,40,53]. Therefore, carbon emissions trading may be effective to help China to realize the potential gains or to reduce the economic output loss from carbon emissions control. This also explains the attempt of Chinese government to establish the pilot carbon emissions trading market in the 12th FYP period. Since China has only recently launched its seven pilot trading markets, and the identified potential gains from trade will be the primary argument for introducing tradable permits and establishing a national emissions trading system in China in the coming five years, it is very interesting to find out what will be the theoretical potential gains, or the abatement cost savings, from trading carbon emissions in China among different provinces.

In this study, we try to answer this question through an ex post analysis based on China's regional data over the period of 2006–2010 and through utilizing a data envelopment analysis (DEA) based optimization model associated with three trading schemes, i.e., no tradable permits (or command and control) scheme, spatial tradable permits scheme, and spatial–temporal tradable permits scheme. During the 11th FYP period, there was no carbon emissions trading pilot market in China, and the regulations on energy consumption intensity reduction were implemented as command and control policies at the national and provincial levels for carbon emissions control. Thus, the observed carbon emissions and economic output (GDP at national level or GRP at provincial level) of the 11th FYP period are taken as the baseline for estimating the potential gains from spatial tradable permits scheme and spatial–temporal tradable permits scheme. These estimated potential gains also imply the abatement cost savings, or the reductions on GDP loss caused by carbon emissions control, from carbon emissions trading at the national and provincial levels.

In specific, the command and control scheme seeks the maximum provincial GRP output subject to the regulated carbon emissions of each province not be exceeded, which represents a no tradable emissions permits scheme. The spatial tradable scheme maximize the regional GRP outputs given that the carbon emissions permits can be reallocated among different provinces, but the national total emissions permit could not be exceeded in each year. The spatial–temporal tradable scheme search the maximum GRP outputs for all provinces given that carbon emissions permits can be reallocated among different provinces and in different years, but keeping the national total emissions permit over the entire study period non-increasing. If a higher level of production of GRP than the observed GRP, i.e. GRP under the command and control policy, can be achieved while maintaining the observed or regulated level of carbon emissions through implementing the carbon emissions trading scheme, then the increase of GRP demonstrates the potential gains from carbon emissions trading. In specific, potential gains estimated by spatial tradable scheme reveal the unrealized abatement cost savings or the potential reductions on GRP loss associated with eliminating spatial regulatory rigidity on carbon emissions trading, and potential gains estimated by spatial–temporal tradable scheme denote the unrealized abatement cost savings or the potential reductions on GRP loss associated with eliminating both spatial and temporal regulatory rigidity on carbon emissions trading. The potential gains from trading estimated in this study provide an upper limit on the potential cost of transaction of carbon emissions trading, and the associated carbon emissions reduction potentials from trading identified in this study provide one argument for implementing a market based policy instrument of carbon emissions trading scheme in China for carbon emissions control.

2. Literature review

There have been several previous researches attempt to analyze the influence of introducing emissions trading mechanism in China. Some researches provided overviews on the status of China's current emissions trading pilot markets, and other researchers investigated the economic impact and the emissions reduction effect of emissions trading scheme in China. These researches also can be divided into studies that focus on estimating the impacts of emissions trading in China at the national level, the regional level (especially for the pilot markets), and the industrial sector level (electricity, building, transportation, etc.).

The first group of studies focuses on introducing China's pilot emissions trading market. Jotzo and Löschel [22] and Zhang et al. [50] provided comprehensive overviews of the current status of China's seven emission trading pilot cities and provinces. They pointed out that there exist large differences on the design features in these pilots which reflecting the diverse settings and proprieties of the emissions trading schemes. The challenges of